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Species of *Hymenochaete* (Hymenochaetales, Basidiomycota) on bamboos from East Asia, with descriptions of two new species

Ting Nie[1,*], Yan Tian[1,*], Shi-Liang Liu[1], Jiao Yang[1], Shuang-Hui He[1]

1 *Institute of Microbiology, Beijing Forestry University, Beijing 100083, China*

Corresponding author: *Shuang-Hui He* (shuanghuihe@yahoo.com)

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Abstract

Six species of *Hymenochaete* are found on bamboos in East Asia. Among them, *H. bambusicola* and *H. orientalis* are described and illustrated as new to science. *Hymenochaete bambusicola* is found exclusively on dead bamboos in northern Thailand and southwestern China, and characterized by the presence of dendrohyphidia and skeletal hyphae. It is phylogenetically and morphologically closely related to *H. innexa*, *H. koeljalgii* and *H. tropica*. *Hymenochaete orientalis* is found on bamboos in Taiwan and on angiosperm branches in southern China. It is distinguished by the absence of a hyphal layer and by having relatively large, oblong-ellipsoid to cylindrical basidiospores. *Hymenochaete orientalis* is morphologically similar to *H. longispora* and *H. cinnamomea*, and forms a distinct lineage close to *H. cinnamomea* in the ITS+nrLSU based phylogenetic analyses. An identification key to the six species on bamboos is given.

Key words

Bambusicolous fungi, Hymenochaetaceae, hymenochaetoid fungi, taxonomy

Introduction

Species of *Hymenochaete* Lév. are readily recognized by having brown basidiomes turning black in contact with potassium hydroxide, characteristic setae, generative hyphae without clamp connections, and smooth, thin-walled basidiospores. *Hymenochaete* is a

* These authors contributed equally to the paper.

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large, morphologically heterogenous genus that includes more than one hundred and twenty species (Léger 1998, Parmasto 2004, Parmasto and Gilbertson 2005, He and Li 2011a, b, He and Dai 2012, Parmasto 2012). Wagner and Fisher (2002) separated the genus *Pseudochaete* T. Wagner & M. Fisch. from *Hymenochaete* according to phylogenetic analyses of nuclear large subunit ribosomal DNA sequences. Subsequently, this separation was supported by several molecular studies, and more species were described in or transferred to *Pseudochaete* (Larsson et al. 2006, He and Dai 2012, He and Li 2013, Parmasto et al. 2014). Yang et al. (2016) proposed *Hymenochaetopsis* S.H. He & Jiao Yang to replace *Pseudochaete*, since the latter has been used for algae since 1903. On the other hand, species in *Cyclomyces* Kunze ex Fr. and *Hydnochaete* Bres., with poroid/cyclolamellate and hydnoid hymenophores, were nested within the clades *Hymenochaetopsis* and *Hymenochaete* in the phylogenetic studies (Wagner and Fisher 2002, He and Dai 2012, Baltazar et al. 2014, Parmasto et al. 2014). Now, the former two genera are treated as synonyms of *Hymenochaete* (Fischer and Wagner 2001, Baltazar et al. 2014).

Although *Hymenochaete* s.l. is widely distributed in subtropical and tropical areas on angiosperm substrates, only one species, *H. muroiana* I. Hino & Katum., has been reported on bamboos in eastern Asia to date (Léger 1998, Parmasto 2005, Parmasto and Gilbertson 2005). In 2015 and 2016, several field trips were carried out in southern China, northern Thailand and central Taiwan, and many corticioid fungal specimens including those of *Hymenochaete* on bamboos were collected. Morphological and molecular studies of the specimens revealed six species of *Hymenochaete* on bamboos, two of which, *H. bambusicola* and *H. orientalis*, are described here as new.

Materials and methods

Morphological studies. Voucher specimens are deposited in the herbaria of Beijing Forestry University, Beijing, China (BJFC), the Center of Excellence in Fungal Research, Mae Fah Luang University, Chiang Rai, Thailand (MFLU), and the National Museum of Natural Science, Taichung, Taiwan (TNM). Samples for microscopic examination were mounted in cotton blue and 2% potassium hydroxide (KOH). The following abbreviations are used: L = mean spore length, W = mean spore width, Q = L/W ratio, n (a/b) = number of spores (a) measured from given number of specimens (b). Color codes and names follow Kornerup and Wanscher (1978).

DNA extraction and sequencing. A CTAB plant genome rapid extraction kit-DN14 (Aidlab Biotechnologies Co., Ltd) was employed for DNA extraction and PCR amplification from dried specimens. The ITS region was amplified with the primer pair ITS5 and ITS4 (White et al. 1990) using the following procedure: initial denaturation at 95 °C for 4 min, followed by 34 cycles at 94 °C for 40 s, 58 °C for 45 s and 72 °C for 1 min, and final extension at 72 °C for 10 min. The nrLSU gene region was amplified

with the primer pair LR0R and LR7 (Vilgalys and Hester 1990, Lapeyre et al. 1993) using the following procedure: initial denaturation at 94 °C for 1 min, followed by 34 cycles at 94 °C for 30 s, 50 °C for 1 min and 72 °C for 1.5 min, and final extension at 72 °C for 10 min. DNA sequencing was performed at Beijing Genomics Institute, and the sequences were deposited in GenBank (Table 1).

Phylogenetic analyses. The molecular phylogeny was inferred from a combined dataset of ITS and nrLSU sequences. The sequences retrieved from open databases originated from He and Dai (2012), He and Li (2013) and Parmasto et al. (2014, Table 1). *Fomitiporia banaennsis* Y.C. Dai and *F. punctata* (P. Karst.) Murrill were selected as outgroup taxa (He and Li 2013). Sequences were aligned using the ClustalX 1.83 (Chenna et al. 2003). Alignments were optimized manually in BioEdit 7.0.5.3 (Hall 1999). Trees were shown in TreeView 1.6.6 (Page 1996).

Maximum likelihood (ML) and maximum parsimony (MP) analyses were conducted for the dataset. MP analysis were performed using PAUP* 4.0b10 (Swofford 2002). Gaps in the alignments were treated as missing data. Trees were generated using 100 replicates of random stepwise addition of sequence and tree-bisection reconnection (TBR) branch-swapping algorithm, with all characters given equal weight. Branch supports for all parsimony analyses were estimated by performing 1000 bootstrap replicates (Felsenstein 1985) with a heuristic search of 10 random-addition replicates for each bootstrap replicate. Max-trees were set to 5000, branches of zero length were collapsed and all parsimonious trees were saved. The tree length (TL), consistency indices (CI), retention indices (RI), rescaled consistency indices (RC) and homoplasy index (HI) were calculated for each generated tree. RAxML v.7.2.6 (Stamatakis 2006) was used for ML analysis. Default setting were used for all parameters in the ML analysis, and statistical support values were obtained using nonparametric bootstrapping with 1000 replicates (Hillis and Bull 1993).

Phylogeny results

The ITS+nrLSU sequences dataset contained 66 ITS and 69 nrLSU sequences from 69 samples representing 59 ingroup taxa and two outgroup taxa (Table 1). Eight ITS and 21 nrLSU sequences were newly generated. The dataset had an aligned length of 2226 characters, of which 611 were parsimony informative. MP analysis yielded 13 equally parsimonious trees (TL = 3172, CI = 0.397, RI = 0.734, RC = 0.291, HI = 0.603). ML analysis resulted in a topology similar to that of MP analysis. Only the MP tree is provided with both parsimony and likelihood bootstrap ≥ 70% labeled along the branches (Fig. 1). Alignments and trees are deposited at TreeBASE (submission ID: 20657). In the tree, samples of *H. bambusicola* and *H. orientalis* formed two distinct lineages. For *H. innexa* G. Cunn., *H. orientalis* and *H. rhabarbarina* (Berk.) Cooke, samples collected from bamboos and wood clustered together with high bootstrap values (Fig. 1).

Table 1. Taxa with locality and GenBank accession numbers for ITS and nrLSU sequences used in the phylogenetic analysis.

Taxa	Voucher	Locality	ITS	28S
Hymenochaete acerosa	He 338	China: Xizang	JQ279543	JQ279657
Hymenochaete adusta	He 207	China: Guangdong	JQ279523	KU975497[a]
Hymenochaete anomala	He 592	China: Hainan	JQ279566	JQ279650
Hymenochaete asetosa	Dai 10756	China: Hainan	JQ279559	JQ279642
Hymenochaete attenuata	He 28	China: Hainan	JQ279526	JQ279633
Hymenochaete bambusicola	He 4116	Thailand: Chiang Mai	KY425674[a]	KY425681[a]
Hymenochaete bambusicola	He 4121	Thailand: Chiang Mai	KY425675[a]	KY425682[a]
Hymenochaete biformisetosa	He 1445	China: Yunnan	KF908247	KU975499[a]
Hymenochaete cana	He 1305	China: Guangxi	KF438169	KF438172
Hymenochaete cinnamomea	He 755	China: Heilongjiang	JQ279548	JQ279658
Hymenochaete cinnamomea	He 2074	USA: Minnesota	KU975460[a]	KU975500[a]
Hymenochaete cruenta	He 766	China: Heilongjiang	JQ279595	JQ279681
Hymenochaete cyclolamellata	Cui 7393	China: Guangdong	JQ279513	JQ279629
Hymenochaete denticulata	He 1271	China: Guangxi	KF438171	KF438174
Hymenochaete epichlora	He 525	China: Hainan	JQ279549	JQ279659
Hymenochaete floridea	He 536	China: Hainan	JQ279597	JQ279683
Hymenochaete fulva	He 640	China: Yunnan	JQ279565	JQ279648
Hymenochaete huangshanensis	He 432	China: Anhui	JQ279533	JQ279671
Hymenochaete hydnoides	He 245	China: Hunnan	JQ279590	JQ279680
Hymenochaete innexa	He 446	China: Anhui	JQ279585	JQ279673
Hymenochaete innexa	He 4640	China: Taiwan	—	KY425683[a]
Hymenochaete koeljalgii	TFC 1996-007	Tanzania: Tanga	—	HE651003
Hymenochaete longispora	He 217	China: Guangdong	JQ279537	KU975514[a]
Hymenochaete luteobadia	He 8	China: Hainan	JQ279569	KU975515[a]
Hymenochaete megaspora	He 302	China: Xizang	JQ279553	JQ279660
Hymenochaete minor	He 933	China: Guangxi	JQ279555	JQ279654
Hymenochaete minuscula	He 253	China: Guizhou	JQ279546	KU975516[a]
Hymenochaete murina	He 569	China: Hainan	JQ716406	JQ716412
Hymenochaete muroiana	He 405	China: Xizang	JQ279542	KU975517[a]
Hymenochaete muroiana	He 4044	Thailand: Chiang Rai	KY425676[a]	KY425684[a]
Hymenochaete nanospora	He 475	China: Anhui	JQ279531	JQ279672
Hymenochaete ochromarginata	He 47	China: Hainan	JQ279579	JQ279666
Hymenochaete odontoides	Dai 11635	China: Beijing	JQ279563	JQ279647
Hymenochaete orientalis	He 4601	China: Taiwan	KY425677[a]	KY425685[a]
Hymenochaete orientalis	He 1057	China: Guangxi	KY425678[a]	KY425686[a]
Hymenochaete orientalis	He 1230	China: Guangxi	KY425679[a]	KY425687[a]
Hymenochaete parmastoi	He 867	China: Guangxi	JQ780063	KU975518[a]
Hymenochaete paucisetigera	Cui 7845	China: Jiangxi	JQ279560	JQ279644
Hymenochaete rhabarbarina	He 280	China: Yunnan	JQ279574	KY425688[a]
Hymenochaete rhabarbarina	He 4636	China: Taiwan	KY425680[a]	KY425689[a]
Hymenochaete rhabarbarina	TFC 1995-028	France: La Réunion	—	HE651007
Hymenochaete rhododendricola	He 389	China: Xizang	JQ279577	JQ279653
Hymenochaete rubiginosa	He 1049	China: Guangxi	JQ716407	JQ279667
Hymenochaete separabilis	He 460	China: Anhui	JQ279572	JQ279655

Taxa	Voucher	Locality	ITS	28S
Hymenochaete setipora	Cui 6301	China: Hainan	JQ279515	JQ279639
Hymenochaete spathulata	He 685	China: Yunnan	JQ279591	KU975529[a]
Hymenochaete sphaericola	He 303	China: Xizang	JQ279599	JQ279684
Hymenochaete sphaerospora	He 715	China: Yunnan	JQ279594	KU975531[a]
Hymenochaete tasmanica	He 449	China: Anhui	JQ279582	JQ279663
Hymenochaete tongbiguanensis	He 1552	China: Hainan	KF908248	KU975532[a]
Hymenochaete tropica	He 574	China: Hainan	JQ279587	JQ279675
Hymenochaete ulmicola	He 864	China: Jilin	JQ780065	KU975534[a]
Hymenochaete unicolor	He 468a	China: Anhui	JQ279551	JQ279662
Hymenochaete villosa	He 537	China: Hainan	JQ279528	JQ279634
Hymenochaete xerantica	Cui 9209	China: Yunnan	JQ279519	JQ279635
Hymenochaetopsis corrugata	He 761	China: Heilongjiang	JQ279606	JQ279621
Hymenochaetopsis gigasetosa	He1442	China: Yunnan	KT828670	KT828674
Hymenochaetopsis intricata	He 412	China: Xizang	JQ279608	JQ279624
Hymenochaetopsis lamellata	Cui 7629	China: Guangdong	JQ279603	JQ279617
Hymenochaetopsis laricicola	Dai 13458	China: Heilongjiang	KT828672	KT828676
Hymenochaetopsis latesetosa	He 502	China: Hainan	JQ716405	JQ716410
Hymenochaetopsis olivacea	Dai 12789	USA: Connecticut	KT828678	KT828679
Hymenochaetopsis rigidula	He 379	China: Xizang	JQ279613	JQ279620
Hymenochaetopsis subrigidula	He 1157	China: Yunnan	JQ716403	JQ716409
Hymenochaetopsis tabacina	He 810	China: Jilin	JQ279611	JQ279626
Hymenochaetopsis tabacinoides	Cui 10428	China: Yunnan	JQ279604	JQ279618
Hymenochaetopsis yasudae	He 375	China: Xizang	JQ279615	JQ279627
Fomitiporia bannaensis	MUCL 46950	China: Yunnan	GU461943	EF429218
Fomitiporia punctata	MUCL 47629	Japan	GU461950	GU461982

[a] Sequences newly generated in this study.

Taxonomy

Hymenochaete bambusicola **S.H. He, sp. nov.**
MycoBank: MB819604
Figs 2, 3

Diagnosis. This species is distinguished by the presence of dendrohyphidia and skeletal hyphae and the preferred substrate of bamboo tissues.

Holotype. THAILAND. Chiang Mai Province: Mork Fa, on fallen bamboo, 25 Jul 2016, He 4116 (holotype: BJFC; isotype: MFLU).

Etymology. "*Bambusicola*" (Lat.) refers to growing on bamboo.

Fruiting body. Basidiomes annual, resupinate, effused, closely adnate, coriaceous, at first as small irregular patches, later confluent up to 50 cm long, up to 200 μm thick. Hymenophore smooth, greyish red [7B(3–6)], brownish orange [7C(3–6)], greyish brown (7D3) to light brown [7D(4–6)], not cracked; margin thinning out, light brown [7D(4–8)] to brown [7E(4–8)], usually darker than the hymenophore surface, velvety, up to 1 mm wide. Tissues darkening in KOH.

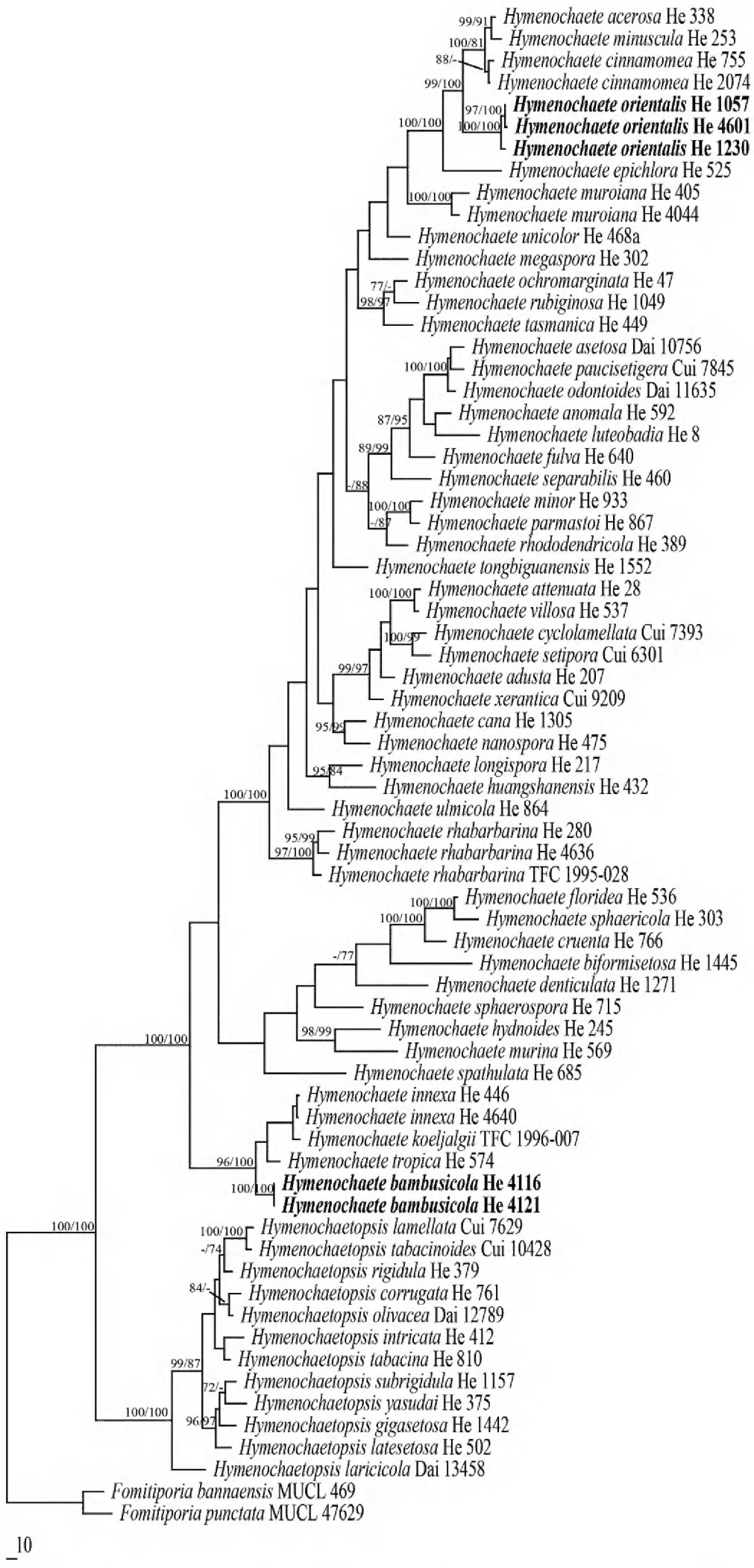
Hymenochaete acerosa He 338
Hymenochaete minuscula He 253
Hymenochaete cinnamomea He 755
Hymenochaete cinnamomea He 2074
Hymenochaete orientalis He 1057
Hymenochaete orientalis He 4601
Hymenochaete orientalis He 1230
Hymenochaete epichlora He 525
Hymenochaete muroiana He 405
Hymenochaete muroiana He 4044
Hymenochaete unicolor He 468a
Hymenochaete megaspora He 302
Hymenochaete ochromarginata He 47
Hymenochaete rubiginosa He 1049
Hymenochaete tasmanica He 449
Hymenochaete asetosa Dai 10756
Hymenochaete paucisetigera Cui 7845
Hymenochaete odontoides Dai 11635
Hymenochaete anomala He 592
Hymenochaete luteobadia He 8
Hymenochaete fulva He 640
Hymenochaete separabilis He 460
Hymenochaete minor He 933
Hymenochaete parmastoi He 867
Hymenochaete rhododendricola He 389
Hymenochaete tongbiguanensis He 1552
Hymenochaete attenuata He 28
Hymenochaete villosa He 537
Hymenochaete cyclolamellata Cui 7393
Hymenochaete setipora Cui 6301
Hymenochaete adusta He 207
Hymenochaete xerantica Cui 9209
Hymenochaete cana He 1305
Hymenochaete nanospora He 475
Hymenochaete longispora He 217
Hymenochaete huangshanensis He 432
Hymenochaete ulmicola He 864
Hymenochaete rhabarbarina He 280
Hymenochaete rhabarbarina He 4636
Hymenochaete rhabarbarina TFC 1995-028
Hymenochaete floridea He 536
Hymenochaete sphaericola He 303
Hymenochaete cruenta He 766
Hymenochaete biformisetosa He 1445
Hymenochaete denticulata He 1271
Hymenochaete sphaerospora He 715
Hymenochaete hydnoides He 245
Hymenochaete murina He 569
Hymenochaete spathulata He 685
Hymenochaete innexa He 446
Hymenochaete innexa He 4640
Hymenochaete koeljalgii TFC 1996-007
Hymenochaete tropica He 574
Hymenochaete bambusicola He 4116
Hymenochaete bambusicola He 4121
Hymenochaetopsis lamellata Cui 7629
Hymenochaetopsis tabacinoides Cui 10428
Hymenochaetopsis rigidula He 379
Hymenochaetopsis corrugata He 761
Hymenochaetopsis olivacea Dai 12789
Hymenochaetopsis intricata He 412
Hymenochaetopsis tabacina He 810
Hymenochaetopsis subrigidula He 1157
Hymenochaetopsis yasudai He 375
Hymenochaetopsis gigasetosa He 1442
Hymenochaetopsis latesetosa He 502
Hymenochaetopsis laricicola Dai 13458
Fomitiporia bannaensis MUCL 469
Fomitiporia punctata MUCL 47629
10

Figure 1. Strict consensus tree obtained from maximum parsimony analysis of combined ITS and nrLSU sequence data of taxa of *Hymenochaete* and *Hymenochaetopsis*. Branches are labeled with parsimony bootstrap (before slash) ≥ 70% and likelihood bootstrap (after slash) ≥ 70%.

Figure 2. Basidiomes of *Hymenochaete bambusicola*. **A** He 4116 (holotype) **B** He 4121. Scale bars : 1 cm.

Microscopic structures. Hyphal system dimitic. Tomentum absent, cortex and hyphal layer present. Cortex up to 10 μm thick, composed of densely interwoven and agglutinated hyphae, sometimes indistinct. Hyphal layer composed of loosely interwoven skeletal and generative hyphae. Skeletal hyphae dominant, golden yellow to yellowish brown, distinctly thick-walled to subsolid, frequently branched, non-septate, 1–3 μm in diam. Generative hyphae scattered, simple-septate, colorless to pale yellow, thin- to thick-walled, moderately branched, 2–5 μm in diam. Setae scattered to abundant, subulate, yellowish to reddish brown, bearing a thick hyphal sheath and an acute tip, without encrustations or sometime slightly encrusted, originating from the subhymenium or the hyphal layer, (55–)70–150(–170) × 7–11 μm, projecting above the hymenium up to 60 μm. Dendrohyphidia numerous, yellowish brown, bearing a thick-walled stem up to 5 μm wide, with branches up to 10 μm long. Basidia clavate to subcylindrical, colorless, with 4 sterigmata and a basal simple septum, 15–18 × 3–4 μm;

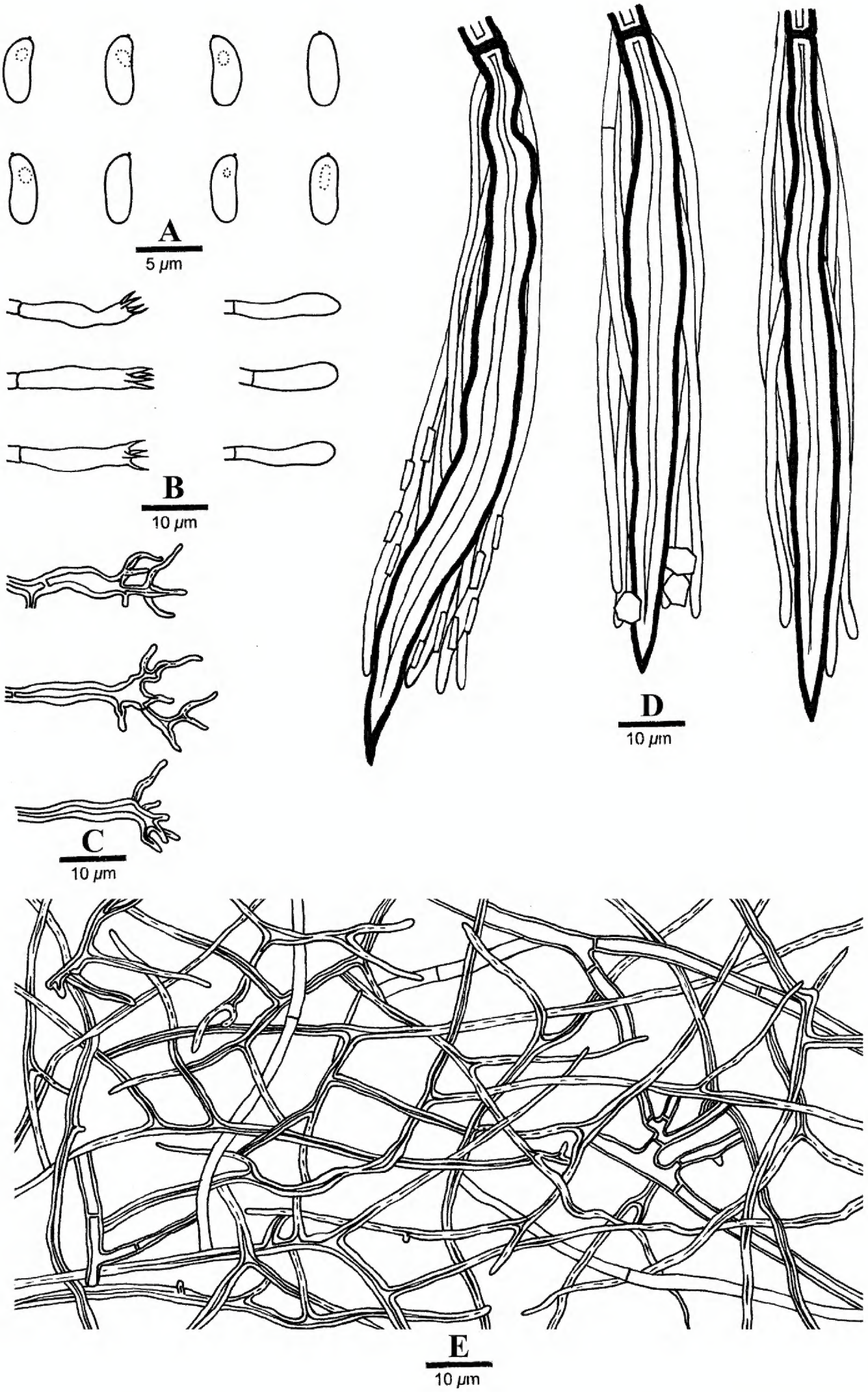

Figure 3. Microscopic structures of *Hymenochaete bambusicola* (drawn from holotype). **A** Basidiospores **B** Basidia and basidioles **C** Dendrohyphidia **D** Setae **E** Hyphae from hyphal layer.

basidioles similar to basidia but smaller. Basidiospores short cylindrical, slightly curved, colorless, thin-walled, smooth, usually with a small guttula, (4–)4.5–6 × 2–2.5(–2.8) μm, L = 5.1 μm, W = 2.2 μm, Q = 2.3 (n = 60/2).

Additional specimens examined (paratypes: BJFC & MFLU). THAILAND. Chiang Mai Province: Mork Fa, on fallen bamboo, 25 Jul 2016, He 4121 & 4131. CHINA. Yunnan Province: Jinghong, Virgin Forest Park, on fallen bamboo, 7 Jun 2011, He 652.

Remarks. *Hymenochaete bambusicola* belongs to sect. *Hymenochaete* sensu Léger (1998) and is morphologically similar to *H. tropica* S.H. He & Y.C. Dai. However, *H. tropica* has a monomitic hyphal system, shorter setae (50–90 × 7–11 μm), and dendrohyphidia with shorter branches (He and Dai 2012). *Hymenochaete innexa* and *H. koeljalgii* Parmasto also resemble *H. bambusicola*, but differ from the latter species by having simple hyphidia (not or rarely branched) and absence of skeletal hyphae (Dai 2010, Parmasto et al. 2014). *Hymenochaete ceratophora* Job [= *H. alabastrina* G.A. Escobar ex J.C. Léger or *Dichochaete ceratophora* (Job) Parmasto] is similar to *H. bambusicola* by having a dimitic hyphal system with thick-walled, branched dichohyphae, numerous dendrohyphidia and short cylindrical basidiospores; however, the former species can be distinguished from the latter by having shorter setae (60–110 × 6–10 μm), crystals in hymenium and subhymenium and a distribution in Mesoamerica and South America on unknown substrates (Léger 1998, Parmasto 2000). *Hymenochaete tasmanica* Massee (sect. *Hymenochaete*) is somewhat similar to *H. bambusicola* by having dendrohyphidia; however, *H. tasmanica* lacks skeletal hyphae, has a stratified subhymenium and grows on angiosperm substrates (Léger 1998). In the phylogenetic tree, *H. bambusicola* formed a fully supported clade with *H. innexa*, *H. koeljalgii* and *H. tropica* (Fig. 1).

***Hymenochaete orientalis* S.H. He, sp. nov.**
MycoBank: MB819605
Figs 4, 5

Diagnosis. This species is distinguished by lacking a hyphal layer and having relatively large, oblong-ellipsoid to cylindrical basidiospores.

Holotype. CHINA. Taiwan: Nantou County, Ren'ai Township, Nandongyan Mountains, on fallen bamboo, 7 Dec 2016, He 4601 (holotype: BJFC; isotype: TNM).

Etymology. "*Orientalis*" (Lat.) refers to the known distribution in East Asia.

Fruiting body. Basidiomes annual, resupinate, effused, closely adnate, crustaceous to coriaceous, at first as small irregular patches, later confluent up to 20 cm long, up to 100 μm thick. Hymenophore smooth, brownish orange [7C(5–8)], light brown [7D (5–8)], brown [7E (5–8)] to reddish brown [8E (4–8)], not cracked; margin indeterminate, concolorous with hymenophore surface. Tissues darkening in KOH.

Microscopic structures. Tomentum, cortex and hyphal layer absent. Hyphal system monomitic. Generative hyphae simple-septate, colorless to pale yellow, moderately

Figure 4. Basidiomes of *Hymenochaete orientalis*. **A** He 4601 (holotype) **B** He 1230. Scale bars: 1 cm.

thick-walled, frequently branched at right angles, densely interwoven, agglutinated, 2.5–4 μm in diam. Setae abundant, subulate, bearing an acute tip, yellowish to reddish brown, arranged in 1–3 overlapping rows, usually with a hyphal sheath and a basal hyphal node composed of densely interwoven hyphae, without encrustations or slightly encrusted with age, 70–120 × 7–10 μm, projecting out of the hymenium up to 85 μm. Basidia clavate to subcylindrical, usually with a constriction in the middle part, some with walls thickening towards the base, colorless, with 4 sterigmata and a basal simple septum, 15–23 × 4–5.5 μm; basidioles similar to basidia but smaller. Basidiospores oblong-ellipsoid to cylindrical, with a small apiculus, colorless, thin-walled, smooth, sometimes with one or two small guttulae, 6–8(–8.5) × 3–3.8(–4) μm, L = 6.7 μm, W = 3.3 μm, Q = 2–2.1 (n = 60/3).

Additional specimens examined (paratypes: BJFC). CHINA. Guangxi Autonomous Region: Jinxiu County, Dayaoshan Nature Reserve, on fallen angiosperm twig, 25 Aug 2011, He 1000; Nanning, Damingshan Nature Reserve, on fallen angiosperm twig, 29 Aug 2011, He 1057; Qingxiushan Park, on fallen angiosperm twig, 15 Jul 2012, He 1230. Guangdong Province: Guangzhou, South China Botanical Garden, on fallen angiosperm twig, 5 Jul 2010, He 235; Heyuan County, Daguishan Forest Park, on fallen angiosperm twig, 18 Aug 2011, He 1212.

Remarks. *Hymenochaete orientalis* belongs to sect. *Gymnochaete* G.A. Escobar ex J.C. Léger sensu Léger (1998), and is morphologically very similar to *Hymenochaete*

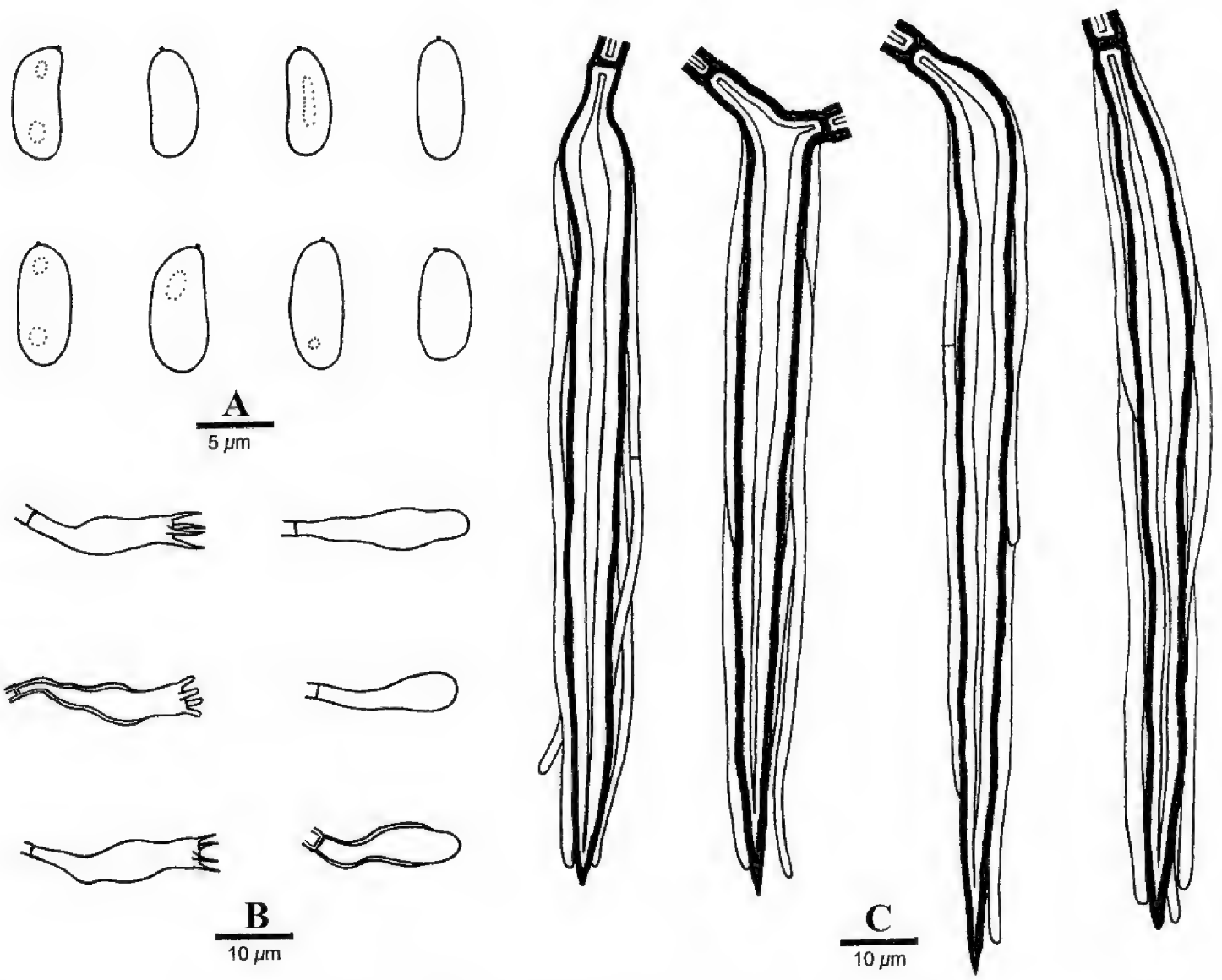

Figure 5. Microscopic structures of *Hymenochaete orientalis* (drawn from holotype). **A** Basidiospores **B** Basidia and basidioles **C** Setae.

longispora Parmasto. However, *H. longispora* has hyphidia in hymenium and longer basidiospores, 8–10 μm according to Léger (1998). *Hymenochaete cinnamomea* (Pers.) Bres. also resembles *H. orientalis*, but differs by the presence of a hyphal layer composed of loosely interwoven hyphae and smaller basidiospores, 5–6.5 × 2.5–3 μm according to Léger (1998). *Hymenochaete minuscula* G. Cunn. in sect. *Gymnochaete* can be distinguished from *H. orientalis* by its smaller setae (40–56 × 5–6 μm) and basidiospores (4–5 × 1.8–2.2 μm) according to Léger (1998). In the phylogenetic tree, *H. orientalis* formed a lineage close to *H. cinnamomea* and *H. minuscula*, but is distant from *H. longispora* (Fig. 1).

Other specimens examined (BJFC)

Hymenochaete innexa: CHINA. Taiwan: Nantou County, Xinyi Township, Xitou Research Center, on fallen bamboo, 11 Dec 2016, He 4640. ***Hymenochaete muroiana***: CHINA. Xizang Autonomous Region: Linzhi County, Gadinggou Forest Park, on dead bamboo, 25 Sep 2010, He 405. Hunan Province: Dong'an County, Shunhuangshan Nature Reserve, on bamboo stump, 13 Jul 2015, He 2379. Hainan Province:

Wuzhishan County, Wuzhishan Nature Reserve, on dead bamboo, 10 Jun 2016, He 3953. Guangdong Province: Zhaoqing County, Dinghushan Nature Reserve, on dead bamboo, 30 Jun 2010, He 172. Guangxi Autonomous Region: Jinxiu County, Dayaoshan Nature Reserve, 23 Aug 2011, He 947. Taiwan: Nantou County, Ren'ai Township, Nandongyan Mountains, on dead bamboo, 7 Dec 2016, He 4608. THAILAND. Chiang Rai Province: Campus of Mae Fah Luang University, on dead bamboo, 21 Jul 2016, He 4044. ***Hymenochaete rhabarbarina***: CHINA. Taiwan: Nantou County, Xinyi Township, Xitou Research Center, on fallen bamboo, 11 Dec 2016, He 4636. ***Hymenochaete tropica***: CHINA. Hainan Province: Wuzhishan County, Wuzhishan Nature Reserve, on fallen bamboo, 10 Jun 2016, He 3959.

Discussion

As shown in previous studies (Larsson et al. 2006, He and Dai 2012, He and Li 2013, Parmasto et al. 2014), species of *Hymenochaetopsis* formed a highly supported clade in our phylogenetic tree (Fig. 1). Four species, *Hymenochaete bambusicola*, *H. innexa*, *H. koeljalgii* and *H. tropica* clustered in a fully supported clade. Morphologically, these species have some similar features, such as strictly resupinate basidiomes, presence of abundant hyphidia, and oblong-ellipsoid to short cylindrical basidiospores. In the phylogenetic tree of Parmasto et al. (2014), *H. koeljalgii* clustered with *H. floridea* Berk. & Broome, but in present analyses the latter species grouped with *H. sphaericola* Lloyd and *H. cruenta* (Pers.) Donk. The topology of these and other closely related species is still not completely resolved. *Hymenochaete orientalis* nested within a highly supported clade with *H. cinnamomea*, *H. minuscula*, *H. acerosa* S.H. He & Hai J. Li, and *H. epichlora* (Berk. & M.A. Curtis) Cooke. This clade includes species of the *H. cinnamomea* group (Parmasto 2001, He and Li 2011a). In Parmasto et al. (2014), *H. cinnamomea* formed a fully supported clade with the generic type *H. rubiginosa* (Dicks.) Lév. and *H. ochromarginata* P.H.B. Talbot; however, in our tree, *H. cinnamomea* group and *H. rubiginosa* group are in a large clade that is not supported. This may be because our phylogenetic analysis includes more taxa related to *H. cinnamomea* and *H. rubiginosa*.

Until now, six species, *H. bambusicola*, *H. innexa* (Fig. 6A), *H. muroiana* (Fig. 6B), *H. orientalis*, *H. rhabarbarina* (Fig. 6C) and *H. tropica* (Fig. 6D) have been found on bamboos in East Asia. Among these species, *H. muroiana*, originally reported from Japan is a common species in East Asia. Parmasto (2012) described *H. muroiana* subsp. *africana* Parmasto on bamboo from Kenya, which is very similar to *H. muroiana* subsp. *muroiana* in morphology. However, it is not clear whether they are conspecific in phylogeny. In addition to *H. muroiana*, *H. bambusicola* is also found exclusively on dead bamboos based on present materials. *Hymenochaete innexa*, *H. rhabarbarina* and *H. tropica* are here reported on bamboos for the first time.

Figure 6. Basidiomes of previously known *Hymenochaete* species on bamboos from East Asia. **A** *H. innexa* (He 4640) **B** *H. muroiana* (He 4608) **C** *H. rhabarbarina* (He 4636) **D** *H. tropica* (He 3959).

Key to species of *Hymenochaete* on bamboos in East Asia

1	Hyphidia present	**2**
–	Hyphidia absent	**4**
2	Hyphal layer absent, hyphidia unbranched	***H. innexa***
–	Hyphal layer present, hyphidia branched	**3**
3	Skeletal hyphae present, hyphidia dendroid with long branches	***H. bambusicola***
–	Skeletal hyphae absent, hyphidia bifurcated to dendroid with short branches	***H. tropica***
4	Hyphal layer present, hyphae encrusted with yellow resinous granules	***H. rhabarbarina***
–	Hyphal layer absent, hyphae smooth	**5**
5	Setae 40–50 µm long, basidiospores 4–6 µm long	***H. muroiana***
–	Setae 70–120 µm long, basidiospores 6–8 µm long	***H. orientalis***

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